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Transportation Energy Management

Transit Operator Facilities
Volume I: Office Guide

DEPARTMENT OF
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FEB 1983

September 1982

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Prepared by

Municipality of Metropolitan Seattle

Prepared for

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Urban Mass Transportation Administration
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FOREWORD

The rapid increase in the price of energy during the 1970's has significantly increased the importance of these expenditures in transit operator budgets. While the bulk of energy expenditures covers vehicle operations, utility costs for fixed facilities have also increased. Indeed, analysis of the 1981 Section 15 report indicates that more than $60 million is now spent annually in this way. Thus transit operators are likely to find it useful to assess possible means of saving money through reducing fixed facility energy usage.

In order to assist transit operators in carrying out such analyses, the Municipality of Metropolitan Seattle has developed this report. We believe it will serve as a useful guide for transit operators wishing to investigate ways of reducing the energy use of their fixed facilities. Many of the suggested measures can be implemented for low or no cost. Others requiring larger investments may be eligible for capital assistance from the Urban Mass Transportation Administration (UMTA).

This document is part of a series of reports on Transportation Energy Management. The first of these, entitled Current Transit Operator Activities, as well as additional copies of this report, may be obtained from our offices, while supplies last, by sending a self addressed label. Also, copies are available from the National Technical Information Service, Springfield, Virginia 22161. Please refer to UMTA-WA-09-0034-83-2 when refering to this report.

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It is based on an energy audit of Metro's East Operating and Maintenance Base. John Graham and Company, the technical consultants on the east base study, provided a preliminary draft. Portions of this handbook were adapted from Seattle City Light's **Energy Management Workbook** and the Washington State Energy Office's **Energy Management Program for Buildings.**

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September 1982

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CHAPTER I

INTRODUCTION

HOW TO USE THIS HANDBOOK

This handbook is designed to help transit systems save energy in bus maintenance, repair and operating facilities by developing and implementing a comprehensive energy conservation program. In the face of rising energy costs, falling revenues and limited funding for new facilities, energy conservation can help management make more efficient use of energy in existing facilities. From this perspective, conservation can be seen as a valuable resource that transit systems can tap to realize substantial savings in operating costs.

This handbook presents practical, step-by-step instructions for developing and implementing a six-part energy conservation program. The program consists of the following elements:

1. An **energy conservation team** to provide organized staff support for the conservation program.

2. An **energy profile** to determine the facility's energy consumption patterns and to establish an energy data base.

3. A **walk-through survey** of the facility to evaluate existing energy systems and practices and to identify potential energy-saving measures.

4. **Implementation of no-cost/low-cost operating and maintenance (O & M) actions** for immediate energy savings from changes in building operations and maintenance procedures that involve no or only minimal costs.

5. **Evaluation of energy conservation measures (ECMs)** to determine the cost-effectiveness of retrofit projects involving changes in the heating, ventilating and air conditioning (HVAC) systems; the roof, walls, doors and other parts of the building envelope; the lighting system and other major energy users.

6. **Establishment of a permanent conservation program** to make energy conservation an ongoing part of transit operations and to develop employees' energy awareness.

The handbook is directed to facility managers, operating and maintenance personnel, building engineers and other staff responsible for the efficient operation of transit facilities. Though some technical ability is required, the handbook is written more for those with day-to-day operating and management responsibilities than for energy conservation experts.

The handbook is divided into two parts. The first part is an office reference guide. It provides a general introduction to energy conservation, an overview of conservation in transit facilities and step-by-step instructions for organizing an energy conservation team, implementing low-cost operation and maintenance (O & M) actions, assessing the cost-effectiveness of energy conservation measures (ECMs) and making conservation a

permanent part of transit operations. This part of the handbook also includes a glossary of energy terms and a bibliography that lists useful references.

The second part of the handbook is a separate field guide. It is made up of the necessary forms and instructions for collecting and analyzing energy consumption data and conducting a walk-through survey to assess the efficiency of existing energy systems and to identify opportunities for conserving energy. Technical reference materials and a case study are included as appendices.

LEARNING TO "SEE" ENERGY

A successful energy conservation program depends on the development of a different way of thinking about energy. As operating staff and management come to think of energy as a resource to be conserved, rather than something to be taken for granted, they will take a new look at the ways energy is used in the facility. For example, by looking at burning lights, open doors and operating compressors as energy users, staff and management will begin to identify potential energy "thieves" or wasters, like a well-lit but unoccupied room or a work area with the heating system running while doors stand open. Developing this kind of energy awareness is an essential goal of any energy conservation program.

To help see energy as a resource that should be conserved, it is useful to look at how energy is conventionally measured and to review the most common terms used to describe units of energy.

In a typical transit facility, some or all of the following kinds of energy may be used for various purposes:

- **Electricity** to light work areas, offices and parking lots; to run machinery, ventilating fans, and air conditioning compressors and, in some cases, to provide comfort heating and hot water.

- **Natural gas, purchased steam** and/or **oil** to provide comfort heating, hot water and power for steam cleaning and similar equipment.

As shown in Figure 1, **measurements of energy,** each kind of energy is measured in different units: electricity in kilowatts or kilowatt hours (Kwh), gas in therms, steam in pounds and oil in gallons. However, energy is most commonly measured in **British Thermal Units** or **BTUs.** By means of standard conversion factors, the various measurements of energy can be transformed into a common unit of measurement--the BTU. Because a BTU is a very small quantity of energy, BTU measurements are commonly expressed in **millions of BTUs** or **MBTUs.** For instance, 1,000 Kwh of electricity can be converted into 3,413,000 BTUs or 3.413 MBTUs.

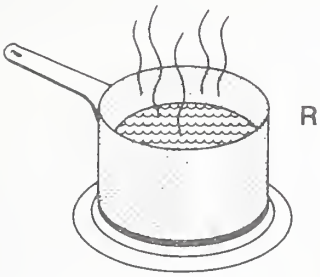
ENERGY USE IN TRANSIT FACILITIES

Transit operating and maintenance facilities come in many varieties. Some are older buildings converted from other uses, like loading and receiving facilities; while others are of recent construction especially designed for maintaining and servicing transit vehicles. Though each building has its own unique features, there are some characteristics common to all. Typically, transit facilities:

FIGURE 1:

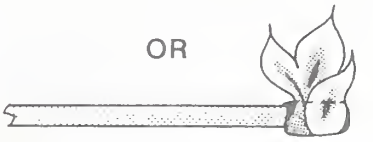
Measurements of Energy

1 BTU (British Thermal Unit) =



1 LB. WATER
RAISED 1°F IN TEMPERATURE

OR



APPROXIMATELY
1 MATCH

1 MBTU = 1,000,000 BTUs or 10^6 BTUs

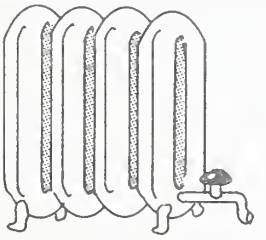
1 KWH (Killowatt Hour) =

100 WATT LIGHT BULB BURNING
FOR 10 HOURS, OR
3,412 BTUs

1 THERM =

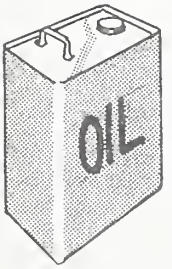
100 CUBIC FEET OF
NATURAL GAS
OR
100,000 BTUs

1 POUND STEAM =
(at atmospheric pressure,
0 PSIG)



970 BTUs

1 GALLON OIL =



140,000 BTUs (#2 fuel oil)
or
160,000 BTUs (#6 fuel oil)

- Combine a variety of uses, including office space, bus repair and maintenance garages, fuel and wash facilities, equipment and parts storage and lounge and locker areas for drivers and mechanics.

- Have continuous to most-of-the-day occupancy.

- Use a large percentage of outside or make-up air to replace exhaust air from paint booths, steam cleaning booths and repair and maintenance areas.

- Require both high lighting levels and quality where close mechanical work is necessary.

- Have a variety of work stations, including repair and maintenance pits and booths for welding, painting and cleaning.

- Are characterized by a high frequency of activity, especially frequent movement of buses and equipment in and out of repair and maintenance areas.

- Have many openings to the outside, such as overhead service doors in repair and maintenance bays, that are frequently open.

Such characteristics have a significant effect on the amount of energy used in a facility, particularly by the lighting and the heating and ventilating systems, for which considerable energy is required. For example, the chart in Figure 2 shows how energy is used in an operating and maintenance facility of recent construction located in the Pacific Northwest.

Though the portion of energy used for each purpose varies with individual facilities and climatic conditions, the general proportions shown in Figure 2 are fairly representative of energy use in a facility combining bus repair and maintenance, offices and employee lounge and locker areas.

As Figure 2 shows, comfort heating typically accounts for the largest single "block" of energy used in a building during the course of a year. In many cases, the heating system was designed with little concern for the energy efficiency of the system. Moreover, most systems were designed to meet extreme conditions, which seldom occur. As a result, many heating systems are oversized and perform in an inefficient manner, thereby providing prime opportunities for conservation.

Using the facility in Figure 2 as an example, some of the major ways energy is used in a transit facility are listed below:

- Comfort heating;

- Ventilation, especially exhaust from separate steam cleaning, welding and paint booths, requiring 100 percent outside air;

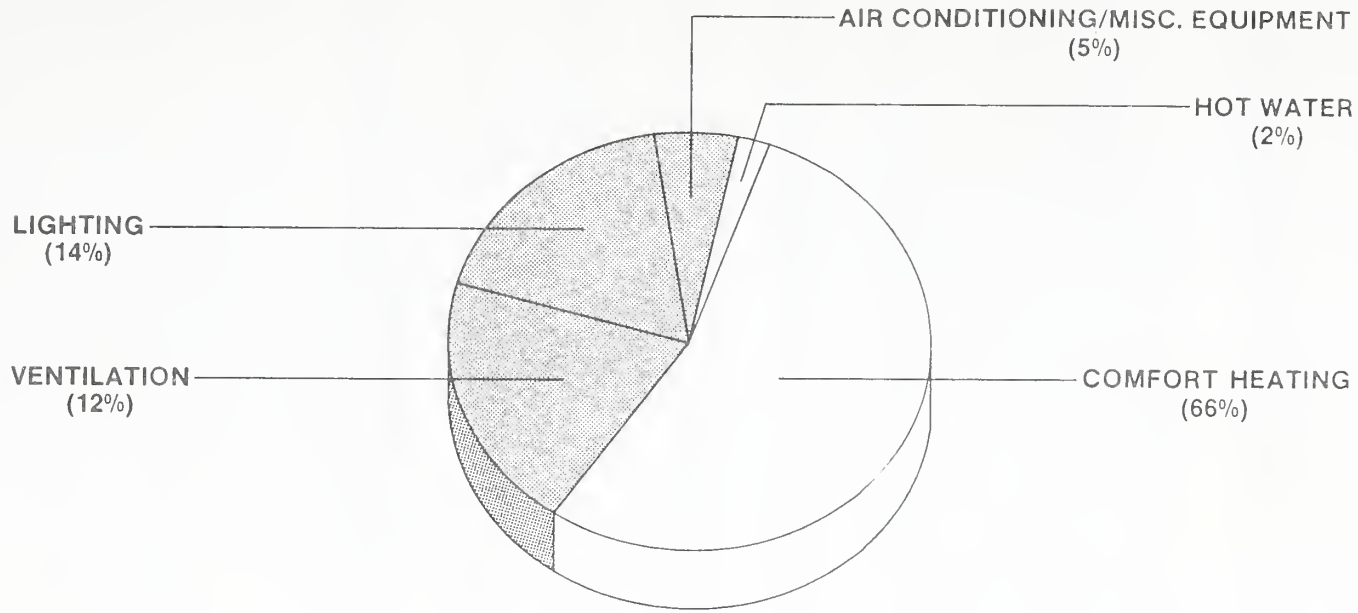
- Heat loss through open bay doors;

- Lighting, both interior and yard;

- Heat loss from uninsulated warm surfaces (e.g., hot water tanks), roofs and walls;

FIGURE 2:

Energy Consumption in a Transit Operating and Maintenance Facility



ENERGY SOURCE

ELECTRICITY (31%)

NATURAL GAS (68%)

- Steam cleaning equipment and electric power tools;
- Air conditioning;
- Compressed air for machinery; and
- Washing equipment.

As this handbook will show, there are significant opportunities for saving energy in most of these areas. A few major opportunities are briefly described in the following section.

ENERGY CONSERVATION IN A TYPICAL FACILITY

Depending on the age, construction and operational characteristics of a facility, the opportunities for energy conservation will vary in terms of cost-effectiveness. However, in most facilities, particularly older buildings constructed before the 1973-74 energy crisis, significant energy conservation opportunities exist, including:

- Modifications to the building envelope (e.g., walls, roofs, doors and windows), such as weather stripping, caulking, adding insulation to roofs and walls and weatherization of exterior doors.
- Lighting system modifications, including installation of local switching, relamping with low-wattage lamps and using energy-efficient fixtures.
- Improvements in the heating, ventilating and air-conditioning (HVAC) system and equipment to reduce energy consumption, enhance efficiency and take advantage of economizer cycles.
- New or additional insulation on existing hot water systems (tanks, condensate receivers, pipes) to reduce heat loss.
- Heat recovery from transit-related industrial processes, such as paint and steam cleaning booths.
- Administrative actions and/or technical devices, such as interlocking the heating system with overhead service doors, to minimize the time that repair and maintenance bay doors are open.

CHAPTER II

AN ACTION PLAN FOR ENERGY CONSERVATION

This chapter presents the basic information for developing and implementing a successful energy conservation program. As shown in Figure 3, there are six essential steps involved in such a program, each of which is described in detail in the Office and Field Guide sections of the handbook.

Though the handbook is primarily designed to assist transit systems in the development of a comprehensive conservation program that includes both no-cost/low-cost operating and maintenance (O & M) actions as well as energy conservation measures (ECMs) requiring capital expenditure, it can also be used to develop a more modest program. This type of program focuses primarily on implementation of O & M actions. Since considerably less technical analysis is required, this approach may be more suitable for systems with limited technical support and resources. Figure 3 shows how the comprehensive program can be modified for this alternate approach by postponing Step 5 to a later date and focusing primarily on the O & M actions discussed in Step 4.

Step 1 - Organize an Energy Conservation Team

The first step in a conservation program is to organize a team of managers, supervisors and operating and maintenance personnel to develop and implement the program. This team approach is an essential ingredient of a successful conservation program because it

- Draws upon the combined expertise of persons who have supervisory and operating experience with the facility,
- Directly involves those who will be responsible for implementing the program, and
- Establishes a structure for future problem-solving regarding efficient use of energy in the facility.

Determine Who Should be Involved

The conservation team should be made up of personnel with "hands-on" experience in the operation and maintenance of the facility, as well as persons with management and supervisory responsibilities. In addition, an in-house specialist in facility energy systems, if available, would be a valuable member of the team.

In selecting the members of the team, there are several important criteria to consider. Ideally the team should be made up of people who:

- Have **operating responsibility**, e.g., staff who are directly responsible for adjusting thermostats, keeping the systems operational and other maintenance duties;

FIGURE 3: STEPS TO ENERGY CONSERVATION

STEP 1	ENERGY CONSERVATION TEAM	Organize a team of managers, supervisors and operating and maintenance staff and obtain technical and organizational support.
STEP 2	ENERGY PROFILE	Determine the overall energy consumption for the facility.
STEP 3	WALK-THROUGH SURVEY	Evaluate the existing energy efficiency of the facility and identify appropriate changes in maintenance and operating procedures.
STEP 4	NO-COST/LOW-COST OPERATION AND MAINTENANCE (O & M) ACTIONS	Modify operating and maintenance procedures and implement other no-cost/low-cost conservation actions.
STEP 5	ENERGY CONSERVATION MEASURES (ECMs)	Determine potential energy savings and implementation costs of capital intensive energy conservation measures and implement the most cost-effective ones.
STEP 6	PERMANENT ENERGY CONSERVATION PROGRAM	Establish on-going monitoring of energy use and development and implement an employee energy awareness program.

- Have some **technical and math ability,** like making basic calculations and understanding heating systems; and
- Are **interested in conservation and willing to participate.**

In order to ensure the most efficient organization for the conservation team, there are a few additional guidelines to keep in mind:

1. Appoint an energy conservation coordinator with overall responsibility for the development and implementation of the program.
2. Assign specific tasks and responsibilities to team members.
3. Limit the team to no more than six or seven members. Too large a team will prove unwieldy and will use up more valuable staff time than necessary.

4. Keep meetings short (one hour or less) and efficient by providing a well-planned and organized agenda.

5. Set realistic goals for the conservation program; for instance, reduction of energy consumption by 15 to 20 percent during the year.

6. Keep communications open by informing staff of the purpose of the program and keeping them up to date on the team's work.

Arrange for Organizational and Technical Support

A key prerequisite to the success of a conservation program is having the support and commitment of top management, not just to investigate conservation opportunities but also to follow through on recommended actions. As a result of the tremendous rise in energy costs, most managers recognize the savings to be realized from conservation. However, in some cases it may be necessary to convince top management or governing authorities of the need for a major conservation effort. Some ways to accomplish this goal include:

- Projecting potential savings by an analysis of utility bills, showing annual energy costs and potential savings from conservation.
- Emphasizing public support for saving energy.
- Undertaking a demonstration program at one building to show the potential savings of a broader conservation effort.
- Obtaining support from conservation programs already underway in local industries, government agencies, and utilities.

The degree of technical support required for a conservation program depends on several factors, such as the relative complexity of the facility's energy systems and how detailed the program will be. Some transit systems may have in-house technical resources, such as energy managers or facility engineers, who can provide the necessary expertise and take the lead in developing a conservation program. However, many systems, especially those with limited support staff, will not have such resources. Though this handbook has been developed with the goal of partially filling that need, it is a good idea to have energy conservation experts available for periodic advice and consultation. Some potential sources of outside support include:

- Local utilities with industrial and commercial conservation programs;
- City, county or state energy offices;
- Energy extension services at state universities;
- Other government agencies, like those concerned with housing, small business and commerce;
- Local industries, universities or institutions with conservation programs in place;
- Vendors and businesses specializing in energy conservation products; and

- Engineering consulting firms.

Seattle is a good example of the kinds of resources available in a local community. In addition to commercial and industrial energy management programs underway at Seattle City Light and other local electrical utilities, the Washington State Energy Office provides technical assistance through its energy management program for public and commercial buildings. Model conservation programs are also in operation at the University of Washington and in several major industries in the area. These and other programs provide a wealth of resources for anyone developing a new conservation program.

STEP 2 - DEVELOP AN ENERGY PROFILE

The main purpose of an energy profile is to get an accurate picture of energy use in a building by showing how much electricity, gas and other forms of energy are currently consumed. This data collection effort is analgous to "BTU bookkeeping." It is the key foundation stone of a conservation program since it will serve as baseline data by which the effects of conservation efforts can be measured.

In general, completion of an energy profile involves collecting data on the total annual energy use in the building, as well as the amount of energy used from each fuel source, e.g., electricity, natural gas or other type of energy. This information can be obtained from fuel and utility bills. See the **Field Guide** for detailed instructions and forms for collecting and analyzing this information.

STEP 3 - CONDUCT A WALK-THROUGH SURVEY

The purpose of this step is to survey the condition and the current operation and maintenance procedures of the building's energy systems. This survey will identify corrective actions, such as resetting thermostats and providing weather stripping around doors to reduce energy consumption. These types of conservation measures involve inexpensive changes in operation and maintenance procedures that can be carried out by maintenance staff.

The key element of this step is the completion of an energy survey checklist. The checklist is reproduced in the **Field Guide** and covers seven categories:

- **Administration,** or the manner in which the building's energy is used, including thermostat settings, hours of operation, maintenance and inspection procedures and similar energy management policies.

- **Lighting,** such as use of the most efficient lighting sources, cleaning of fixtures and optimal use of natural lighting.

- **Building Envelope,** including heat gain in the summer and heat loss in the winter due to infiltration through cracks, around windows and doors and transmission through exterior walls, windows and doors.

- **Ventilation,** or the exchange of inside air for fresh outside air through exhaust fans and the ventilating system.

- **Heating,** such as the furnace, boiler, heat pump or other means of producing heat and the distribution system for heating.

- **Cooling,** including the compressor, coils and distribution system.

- **Water,** or the hot water heater and distribution system for providing domestic hot water.

Each of these can be examined by a standardized checklist to evaluate the energy efficiency of both the systems themselves and the way in which they are used. The result of this step will be a clear picture of how current practices can be modified to save energy without sacrificing adequate lighting, temperature, ventilation and other factors contributing to a comfortable working environment.

STEP 4 - IMPLEMENT NO-COST/LOW-COST OPERATING AND MAINTENANCE (O & M) ACTIONS

Step 4 focuses on conservation actions that, for no or only minimal expense, will make it possible to realize immediate savings by increasing the efficiency of existing energy systems in the facility. Because these no-cost/low-cost measures can provide a significant return for very limited investment, they should be thoroughly examined before turning to the more capital-intensive conservation projects discussed in Step 5.

These no-cost/low-cost actions include changes in operating and maintenance procedures (O & M), such as cleaning light fixtures on a regular basis, reducing hot water temperatures, adjusting ventilation dampers and turning the building's heating/cooling system off during unoccupied periods. In addition, there are also minimal expense conservation actions that can be implemented by maintenance personnel, such as changing to more efficient lights as existing bulbs wear out, weather stripping outside doors or windows, installing tamper-proof thermostats and insulating hot water tanks.

The energy survey checklist in the **Field Guide** provides a comprehensive list of recommended O & M actions. Some of the more common ones are listed below.

Administration

- **Reset thermostats** to 65°F during the heating season and 78°F during the cooling system. Make sure that changing settings does not increase energy usage, i.e., that maintaining a 65°F temperature does not necessitate the use of refrigerated air conditioning and 78°F does not require additional heating in the summer.

- **Make thermostats tamper-proof** by installing locking covers or moving them to an inaccessible area.

- **Relocate thermostats** if they are currently located where the temperature is not typical of the area being served. For example, thermostats should not be mounted on exterior walls where outside temperature may give a false reading, or on interior walls where sunlight will affect them.

- **Reduce thermostat settings** or turn the heating/cooling system off altogether in lobbies, corridors and unoccupied or seldom-used areas. Also, turn the

system off during nights, weekends, holidays and other times the building is empty or has low occupancy.

- **Move desks and work stations** from hot or cold walls and away from drafts.

- **Reschedule off-hour activities** to reduce the need for heat or cooling during periods of low occupancy.

- **Allow the building to "coast"** by reducing or turning off the heating/cooling system during the last hour of occupancy.

- **Reschedule electrical equipment use** to reduce higher demand or "peak" changes. Ask a customer representative from the local utility to explain the way electricity is billed and what the building's electrical use profile is. If the electrical bill includes a charge for peak demand, use monitoring devices (usually available from the utility) to determine when the peak electrical demand occurs. Then reschedule the use of electrical equipment to reduce this peak as much as possible. For example, shifting one kilowatt from peak to off-peak time (e.g., midafternoon and late night) can save as much as $5 per month (national average).

- **Use blinds and curtains** to reduce heat loss at night and on cloudy days during the heating season and to reduce heat gain during the cooling season.

- **Keep doors closed during the heating season,** especially overhead service doors in maintenance bays, by posting notices ("Keep It Closed"), relocating work stations to reduce the number of frequently used doors or establishing and monitoring routine procedures for closing doors.

- **Set up a regular inspection and preventive maintenance program** for the lighting, ventilating, heating and cooling systems.

  Maintenance checks should include:

  - Replacing damaged or worn insulation on ducts, pipes and other heated surfaces;

  - Cleaning light fixtures and replacing worn-out bulbs and ballasts;

  - Cleaning fresh air intake screens, air filters, heating/cooling coils and other heat exchange surfaces;

  - Checking fan belts and pulleys for correct tension and alignment; and

  - Repairing damaged caulking and other openings to the outside.

Lighting

- **Remove all unnecessary lighting** by reducing wattage or removing bulbs. For example, a 40-watt fluorescent lamp operated 3,000 hours each year could cost about $7.50 (national average). Removal and storage of two lamps from each fixture can save about $15 per year per fixture. The stored lamps can be

used later as replacements. Also, remember to disconnect the ballasts since they alone consume approximately 20 percent of electrical energy in fixtures.

- **Install more efficient lamps** to replace burned out ones. Use lower wattage, if possible.

- **Clean all light fixtures** on a regular basis since dust and dirt reduce effectiveness. Also, clean walls and ceilings to provide better reflected light.

- **Post signs and notices** reminding occupants to turn off lights in storage areas, lounges, meeting rooms and infrequently used areas.

- **Relocate desks and work areas** to take advantage of natural light from windows and to use installed lighting fixtures to the best advantage. Also, consider grouping tasks according to illumination requirements. This action can decrease the number of areas requiring high illumination levels, thereby reducing the total amount of lighting needed.

- **Periodically check light output** to determine if older lamps have decreased in efficiency. When the light output of a group of lamps has fallen to approximately 70 percent of the original, relamp all fixtures in the group at the same time. This is also a good time to check whether a more efficient or lower wattage lamp is suitable.

- **Use exterior lighting only when necessary** for safety or security reasons. Make certain outside lights are off during daylight hours.

Building Envelope (Windows, Walls, Doors, Roof and Floor)

- **Replace worn or broken weather stripping and caulking** around exterior windows and doors and in cracks in the building construction. Install caulking and weather stripping if none was installed previously.

- **Rehang misaligned doors and windows.** Also, check automatic door closing mechanisms for tight fit. Install automatic closures, if feasible.

- **Post signs** reminding occupants to keep doors and windows closed when the heating or cooling system is running.

- **Replace broken or cracked window panes.** Use double-paned, insulated glass or install plastic storm windows. Panel over and insulate unnecessary windows.

- **Use mylar film** to reflect sunlight and reduce heat gain through windows.

- **Caulk and weather strip** all exterior joints between walls and foundation or walls and roof as well as all exterior openings for electrical conduits, piping and through-the-wall cooling or heating units.

- **Replace worn or faulty gaskets** in overhead service doors. Seal cracks in sectional doors and make sure the bottom of the door fits tightly with the floor. Install a floor seal if necessary.

Ventilation (Air Supply and Exhaust System)

- **Reduce the quantity of outside or supply air** to the minimum allowed by code and safety requirements. When possible, use outside air for cooling instead of operating the mechanical cooling system.

- **Reduce the quantity of exhaust air** by programming the operation of the exhaust fans and discontinuing use of unnecessary fans. For example, connect toilet exhaust fans to the light switch so fans run only when the lights are on.

- **Inspect all outside air dampers.** They should be as airtight as possible when closed. Check operation of the position indicators for accuracy. Install, repair, or replace position indicators as needed.

- **Inspect filters carefully.** Implement a filter replacement schedule. Use high-efficiency, low-cost filters.

- **Examine the controls for the ventilating system** to see that all of them are working properly and in correct sequence. If they are leaking, the gauges not working, dampers not closing or if it's not clear what they do, energy efficiency can be substantially improved by having the entire system examined by a controls system specialist.

- **Install baffles** to prevent wind from blowing directly into an outdoor air intake.

- **Check and repair** fan belts and motors and check for proper belt alignment.

Heating

- **Reduce use of heating systems** in spaces that are used infrequently or for only short periods of time. For example, consider closing supply registers and radiators and reducing thermostat settings or turning off the electric heaters in storage areas, lobbies, corridors and vestibules.

- **Reset boiler water temperatures** to lower settings during periods of mild weather.

- **Inspect boilers regularly.** For example, remove deposits and sediments and clean burners and heat exchangers regularly. Improving boiler efficiency is one of the most cost-effective ways to save energy, resulting in possible 20 to 30 percent savings in heat costs.

- **Adjust controls on systems with multiple boilers** so that the second boiler fires only when the first no longer satisfies demand. Since boilers run most efficiently at maximum load, it is better to operate one boiler at 90 percent capacity than two at 45 percent capacity each.

- **Check boiler stack temperature.** If it is too high (more than 400°F plus room temperature), clean tubes and adjust fuel burner. Obtain assistance from service contractor if necessary.

- **Make certain heating and cooling systems are not operating simultaneously.** For example, turn off the reheat in all areas during summer, except when equipment requirements necessitate humidity control. Also, ensure that a deadband exists between heating and cooling thermostat settings. In some cases, there may be two thermostats with overlapping or no deadband control, thus creating heating and cooling demand unnecessarily. In such a case, provide maximum and minimum settings on the thermostats (usually this can be done with a small setscrew).

- **Check thermostats for proper operation.** Clean and recalibrate if necessary.

- **Check supply ducts and dampers** for proper operation. Remove loose insulation and other obstructions.

- **Replace worn or missing insulation** on ducts and on steam, condensate and heating water pipes.

- **Turn off pilot lights** during cooling season.

- **Check steam traps** for proper operation. Remove obstructions and clean traps.

- **Discontinue humidification** wherever possible. For example, turn off humidifiers whenever the building is closed for extended periods of time, except when process or equipment requirements take precedence. Also, evaluate the necessity of the humidification system and curtail humidification for areas such as hallways, equipment rooms and lobbies.

- **Clean and maintain radiators,** baseboard heaters and other heat exchange devices. For example, bleed steam radiators with air locks and check traps and control valves.

Cooling

- **Check thermostats and controls** for proper operation. Clean and recalibrate as necessary.

- **Reduce use of cooling system** by using outside air for cooling whenever possible.

- **Operate one of multiple compressors and chillers at full load,** rather than two or more at partial loads.

- **Reset hot and cold decks** on dual duct or multizone system to minimize mixing.

- **Repair or replace worn or missing insulation** on cooling line pipes and ducts. Also, check and repair any leaking pipes.

- **Check ducts, cooling coils and supply grills** for dirt and obstructions. Also, examine dampers for proper operation.

- **Raise chilled water temperature** to optimum level for maintaining comfort.

- **Reduce internal heat generation** as much as possible during the cooling season. Typical sources of heat generation include lighting, people and machines.

- **Lower the cooling effect** in mild weather by running room cooling fans at lower speeds.

- **Flush the building with cooler outdoor air** during evening and night hours.

Domestic Hot Water

- **Check storage tanks, piping and water heaters** for leaks and damaged or missing insulation. Make repairs as necessary. Also, fix leaky faucets.

- **Use the "vacation cycle" on the water heater** during extensive periods when hot water is not needed. Also, cycle hot water use to avoid peak periods of electricity demand.

- **Insert flow restrictors** into showers and faucets. Many utilities provide such restrictors.

- **Reduce hot water temperature to 105°F** unless code or special purposes require higher settings.

STEP 5 - EVALUATE ENERGY CONSERVATION MEASURES (ECMS)

This step focuses on energy conservation measures (ECMs) that require substantial capital expenditure, such as installation of heat recovery devices or more efficient lighting fixtures. Unlike the no-cost/low-cost O & M actions discussed in Step 4, these longer term ECMs require an initial capital outlay that must be amortized by the energy savings generated over their expected lifetime. Because a significant investment is involved, it is necessary to make a technical analysis of the proposed ECM in order to determine its cost-effectiveness. This analysis involves calculations such as the cost of implementing the measure, the estimated savings, the operational life and the effect of the ECM on maintenance costs. Using the information provided by the analysis, management can then decide whether to implement a proposed ECM. For instance, some may provide a reasonably high return on the initial investment, while others can be rejected because of low or negative returns.

The first task for the conservation team is to identify possible ECMs for evaluation. Many will have become apparent during the walk-through survey (Step 3). For example, the conservation team may have noticed an opportunity to reduce electrical consumption by replacing incandescent lights with more energy-efficient fluorescent fixtures. Such ECMs should be grouped under the appropriate category, like administration, lighting and so on. Once a list has been prepared, the next task is to identify which ECMs offer the best opportunity for reducing energy use by estimating the proportion of the total energy use required for each function. For example, since it is likely that comfort heating will constitute the greatest proportion of energy use, ECMs involving the heating system should be given first attention.

Appendix C in the **Field Guide** provides instructions for estimating energy use by function. These calculations require considerably more detailed analysis than for the energy profile and may require solicitation of outside technical assistance. See the **Field Guide** for more details.

Once ECMs have been identified, the next task is to determine whether a measure is cost-effective. To make this analysis, it will be necessary to:

1. **Determine the potential energy savings** of the conservation measure by comparing current energy requirements with the projected energy requirements of the proposed ECM. (The calculations discussed in Appendix C of the **Field Guide** will also be useful here.) Thus, the potential savings of replacing incandescent lighting with fluorescent lighting can be calculated by subtracting the energy requirements of a lighting system with fluorescent lights from the current energy requirements of incandescent lights.

2. **Assess the cost of implementing the measure**, including the cost of the equipment, installation and maintenance. In most cases, vendors, contractors and promotional literature can provide this information. For instance, a lighting firm can be contracted for an estimate of the cost of installing fluorescent lights.

3. **Finally, determine the cost-effectiveness of the measure** by comparing the cost of implementing the ECM with the potential energy savings. This comparison can be made according to two methods:

   - **Simple pay-back or first-level measure of performance**, which does not consider the changing value of money over time, or

   - **Discounted pay-back or second-level measure of performance**, which includes calculations for the time value of money.

In common practice, the proposed ECMs are analyzed according to first-level measures and ranked in order of the payback period from shortest to longest. This process screens out unfeasible ECMs, leaving the most cost-effective conservation measures for further analysis according to second-level measures of performance. The results of these second-level measures will more accurately show the actual savings of an ECM.

Detailed formulas for first- and second-level measures are discussed below, along with sample calculations. (Note that data requirements for these calculations involve the more detailed analysis of energy consumption discussed in Step 2 in the **Field Guide.**) Following these calculations is a list of some of the more common ECMs that can be considered in improving the energy efficiency of transit facilities.

First-Level Measures of Performance

First-level measures are useful in screening out uneconomic ECMs without the application of more sensitive second-level measures. In general, however, first-level measurements should not be used for justifying major investments for energy conservation projects, since this approach does not reflect the time value of money.

There are two types of first-level measures: **simple pay back period and return on investment.** Calculations for each of these require the following information:

- **First-Cost of Retrofit (FC)**, or the estimated dollar cost of labor and materials required to implement the proposal. This information can be obtained from vendors, contractors, utilities and promotional literature.

- **Annual Fuel Savings (AFS),** which is determined by subtracting the energy requirements after implementation of the proposed conservation measure from the energy requirements of the existing system.

- **Projected Fuel Price (PFP),** which represents an average fuel price during the estimated lifetime of the measure. It is important to use projected prices since the use of current prices will result in lower total savings than can be reasonably expected, thereby inducing a bias against energy conservation investments. Local utilities can be contacted for information about fuel price projections.

- **Annual Operating Costs (AOC),** or those new, recurring costs, if any, of operating the ECM that would not be incurred under existing conditions. For instance, a proposal to install automatic, motorized openers on service bay doors would involve new operating costs compared to a manually operated system. However, replacing incandescent with fluorescent lighting would not.

- **Estimated Lifetime (EL),** which is the projected useful life of the proposed measure. Manufacturer's specifications are the best source for this information.

Using these elements, the

- **Net Annual Savings (S)** of a proposed measure can be determined by the formula:

$$S = (AFS \times PFP) - AOC$$

The Simple Payback Period (PP) is then determined by the first cost divided by the net annual savings, or

$$PP = \frac{FC}{(AFS \times PFP) - AOC} \quad \text{or} \quad \frac{FC}{S}$$

The payback period is then compared to the expected lifetime of the investment in order to make a rough judgment of the potential for recovering the investment. Roughly, a payback period of less than one-half the lifetime of an investment is generally considered cost effective. For example, where the lifetime is ten years, a payback period of five years or less would indicate a good investment.

Return on Investment (ROI) is a second way of evaluating first-level measures of performance. It is somewhat superior to the simple pay back period method because it takes into account the depletion of the investment over its economic life by providing for renewal through a depreciation charge.

Using a straight line **Depreciation Charge (DC),** where

$$DC = \frac{\text{First Cost}}{\text{Estimated Lifetime}} \quad \text{or} \quad \frac{FC}{EL},$$

The percent ROI can be calculated:

$$\text{ROI (percent per year)} = \frac{\text{Savings - Depreciation Charge}}{\text{First Cost}} \times 100\% \quad \text{or} \quad \frac{S - DC}{FC}$$

ROI has the advantage of putting investments with different life expectancies on a comparable basis. Where the return on investment is small (e.g., less than 20 percent), second-level measurements are called for in order to bring the time value of money into the analysis.

Sample First-Level Analysis

- **Proposed Energy Conservation Measure (ECM):**

  Replace incandescent lighting with fluorescent lights in the lobby and corridors.

- **Discussion:**

  The purpose of incandescent lighting in the lobby and corridors is to illuminate the front desk and the bulletin boards. This may be done more efficiently with fluorescent lighting, especially since the facility is in continuous operation, 24 hours a day, 365 days a year.

- **Implementation Cost/First Cost of Retrofit:**

10 single lamp fluorescent fixtures @ $85 each	$ 850
Remove 12 existing incandescent fixtures @ $20 each	240
Contingency	50
Subtotal	1,149
Support Services	100
Total Cost of Retrofit	$1,249

- **Annual Fuel Savings:**

  - Existing Conditions:

    1. Lighting Load: 1800 w or 1.8 kw

    2. Annual Consumption: 1.8 kw x 8,760 hrs/yr = 15,768 kwh/yr

- Conditions After Retrofit:

  1. Lighting Load: 520 w or .5 kw

  2. Annual Consumption: .5 w x 8,760 hrs/yr = 4,381 kwh/yr

- Fuel Savings: 15,768 kwh/yr - 4,381 kwh/yr = 11,387 kwh/yr

o **Projected Fuel Price:** Electricity at $.0309/kwh

o **Annual Operating Cost:** $0.00

o **Useful Life/Estimated Lifetime:** 20 years

o **Effect on Maintenance Cost:**

Maintenance cost will be decreased due to longer lamp life of fluorescent lamps.

o **Simple Payback Period:**

$$\frac{\$1,249}{(11,387 \text{ kwh/yr} \times \$.0309/\text{kwh}) - 0} = \frac{FC}{S} = \frac{\$1,249}{\$352/\text{yr}} = 3.6 \text{ years}$$

o **Return on Investment:**

$$\text{Depreciation Charge} = \frac{\$1,249}{20 \text{ years}} = \$62.45/\text{yr}$$

$$\text{ROI} = \frac{\$352/\text{yr} - \$62.45/\text{yr}}{\$1,249} \times 100\% = 23\%$$

o **Conclusion:**

Because of the short payback period in comparison to the estimated lifetime of the proposal (3.6 to 20 years), the high ROI (23 percent) and the projected decrease in maintenance cost, this is a highly recommended, cost-effective measure.

Second-Level Measures of Performance

Unlike first-level measures of performance, second-level measures incorporate an allowance for the time value of money, generally in the form of a discount factor. Because second-level measures take into account energy price escalation, they are more acurate in estimating the actual savings of an energy measure over its lifetime.

Benefit/Cost Analysis or more commonly, **Life Cycle Cost (LCC) Analysis,** is widely used as a second-level performance measure in energy management. LCC provides the major

benefit of considering all costs of a product, device or system that accumulate over its useful life. Typical costs include those to design, purchase, install, maintain and operate the device. LCC calculations are especially valuable since they may show that a product which is twice as expensive as another actually may be only half as expensive on a life-cycle basis.

Life cycle cost analysis requires the direct comparison of the **Present Value (PV)** benefits or savings, generated by a given investment, with its costs. Generally, LCC is formulated in terms of a **Benefit/Cost Ratio (B/C).** A B/C ratio greater than one implies that the expected net benefits (properly discounted and summed over the lifetime of the investment) will exceed the initial costs and that, therefore, such an investment is profitable.

The **Present Value (PV)** of future savings is expressed in terms of the **Present Worth Factor (PWF)** and **Net Annual Savings (S):**

$$PV = S \times PWF, \text{ where}$$

$$S = (\text{Annual Fuel Savings} \times \text{Projected Fuel Price}) - \text{Annual Operating Cost}$$

or

$$S = (AFS \times PFP) - AOC^*$$

and where,

PWF is equal to the relationship between the **Discount Rate (D),** which accounts for escalation in energy and related costs, and the **Estimated Life (EL)** in years of the conservation measure, as expressed in Table 1.

The **Benefit/Cost ratio (B/C)** is then defined as:

$$B/C = \frac{\text{Present Value (PV)}}{\text{First Cost (FC)}}$$

* See preceding discussion of first-level measures of performance.

TABLE 1: PRESENT WORTH FACTORS

Lifetime (EL)	Discount Rate (D)				
	5%	10%	15%	20%	25%
1	0.952	0.909	0.870	0.833	0.800
2	1.859	1.736	1.626	1.528	1.440
3	2.723	2.487	2.283	2.106	1.952
4	3.546	3.170	2.855	2.589	2.362
5	4.329	3.791	3.352	2.991	2.689
6	5.076	4.355	3.784	3.326	2.951
7	5.786	4.868	4.160	3.605	3.161
8	6.463	5.335	4.487	3.837	3.329
9	7.108	5.759	4.772	4.031	3.463
10	7.722	6.145	5.019	4.192	3.571
11	8.306	6.495	5.234	4.327	3.656
12	8.863	6.814	5.421	4.439	3.725
13	9.394	7.103	5.583	4.533	3.780
14	9.899	7.367	5.724	4.611	3.824
15	10.380	7.606	5.847	4.675	3.859
16	10.838	7.824	5.954	4.730	3.887
17	11.274	8.022	6.047	4.775	3.910
18	11.690	8.201	6.128	4.812	3.928
19	12.085	8.365	6.198	4.843	3.942
20	12.462	8.514	6.259	4.870	3.854
21	12.821	8.649	6.312	4.891	3.963
22	13.163	8.772	6.359	4.909	3.970
23	13.489	8.883	6.399	4.925	3.976
24	13.799	8.985	6.434	4.937	3.981
25	14.094	9.077	6.464	4.948	3.985

Sample Second-Level Analysis

- **Proposed Energy Conservation Measure (ECM):**

  Install device to recover waste heat from exhaust air.

- **Discussion:**

  The air handling unit supplying the steam cleaning room provides 100 percent outside air as the makeup for the exhaust system. Since the average outdoor air temperature in the heating season is 49.6°F and the exhaust air temperature is 65°F, considerable heat can be recovered with a heat exchanger. Additional ductwork and modification of controls will be required in addition to the heat recovery unit. The exhaust air temperature of 65°F is based upon doors being closed except when buses are entering or leaving. If the doors are left open, energy savings will be reduced considerably.

- **Implementation Cost/First Cost of Retrofit:**

Change Fan Motor Drives	$ 200
Change Fan Motor	1,390
Intake Louver	650
Ducts	1,870
Relocate Control Dampers	1,000
Heat Recovery Device (heat pipe coil)	6,070
Subtotal	11,180
Support Services Design Costs	1,800
Total	$12,980

- **Annual Fuel Savings:**

Given Supply Air Velocity at	12,000 cfm
Exhaust Air Volumetric Rate at	12,000 cfm
Flow Ratio =	$\frac{12,000}{12,000} = 1.0$

Manufacturer's specifications for a 4 row-14 fin/inch coil at 500 RFPM face velocity shows a heat recovery factor of 0.54.

Adjusted recovery factor $= \frac{0.54}{1.0} =$ (0.54 based on supply air).

Operating time = 24 hours per day, 7 days per week.

Then, Gross Energy Savings = 1.08 BTU/cfm -°F-hr x 12,000 cfm

$$\times \frac{.54\ (65^{o}F - 49.6^{o}F) \times 343 \text{ days/yr} \times 24\text{-hr/day}}{0.8 \text{ Plant Efficiency}}$$

$= 1{,}109 \times 10^{6}$ BTU/yr, or 1,109 MBTU/yr.

- **Projected Fuel Price:**

  Natural Gas at $.497/therm x 10 (1 MBTU = 10 therms) = $4.97/MBTU

- **Annual Operating Cost:**

  Energy for additional fan horsepower = (4.6 - 3.09) hp + (6.0 - 3.55) hp

  x .746kw/hp x 365 days/yr x 24-hrs/day

  = 25,878 kwh/yr x $0.0309/kwh = $800/yr.

- **Useful Life/Estimated Lifetime:** 20 years

- **Present Value of ECM:**

  PV = S x PWF, where

  S = (AFS x PFP) - AOC = (1,109 MBTU x $4.97/MBTU) - $800/yr = $4,712

  PWF = 4.870 (20% Discount Rate over 20-year lifetime)

  PV = $4,712 x 4.870 = $22,947

- **Benefit/Cost Ratio of ECM:**

$$B/C = \frac{PV}{FC} = \frac{\$22{,}947}{\$12{,}980} = 1.73$$

- **Conclusion:**

  Because of the high benefit/cost ratio, this is a highly recommended measure. Calculation of first-level performance measures reinforce this conclusion, with a simple payback period of 2.75 years and a ROI of 31 percent.

Possible Energy Conservation Measures (ECMs)

Listed below are common energy conservation measures to consider as retrofit projects for transit facilities. This list is not exhaustive; other conservation measures identified during the walk-through survey (Step 3) should also be included. Finally, note that many of these measures can be incorporated in plans for new facilities.

Administration

- **Install a night setback thermostat** to automatically adjust thermostat settings on nights, weekends and other periods of low occupancy.

- **Change thermostats for combination heating/cooling systems to "dead band" type,** which will allow cooling and heating setpoints to be separated, thereby providing a zero energy band where neither heating nor cooling is required.

- **Install a centralized, computer-operated energy management control system** to ensure the most efficient use of the building's lighting, heating, cooling and other major energy consuming systems. (Note: This type of system is most appropriate for facilities with inconsistent operation, e.g., not 24 hours per day, and with fluctuation in heating and cooling loads.)

- **Install a demand controller** to monitor electrical energy demand and reduce the electrical load during peak demand periods by turning off predetermined equipment, like air conditioning compressors, pumps, lighting and water heaters.

  (Note: For this measure to be effective, demand peaks must be relatively high and of relatively short duration--one to two hours--in comparison with normal usage.)

Lighting

- **Install energy-efficient high pressure sodium fixtures** in constantly lit areas, such as shops and fuel and wash areas. For parking and exterior yard lighting, low pressure sodium fixtures should be considered.

- **Lower the height** of existing lighting fixtures to increase efficiency.

- **Replace incandescent lighting with fluorescent lighting** in offices, corridors, lobbies, lounges, work areas and elsewhere. Where lights are on more than 3,000 hours per year (eight hours a day), fluorecent lighting is much more cost-effective than incandescent lighting.

- **Place lighting on local switching** in areas that are not used on a 24-hour basis, like storage areas and employee lounges and locker rooms. In such areas that already have switching, consider installing automatic, timed switches.

- **Install dimmer switches or multi-level fixtures** to allow for variation in lighting levels as needed.

- **Relamp fluorescent fixtures with low-wattage lamps** in areas where it is possible to allow for the ten percent reduction in lighting levels resulting from the installation of low-wattage lamps. (Note: This conservation measure can also be done gradually by replacing burnt-out lamp with low-wattage ones. As such, it should be considered an O & M action.)

- **Install Task-lighting** wherever possible to enable reduction of overall lighting requirements.

- **Install photocells** to turn off exterior lighting during daylight hours.

- **Increase natural lighting** by installing skylights.

Building Envelope (Windows, Walls, Doors, Roof and Floor)

- **Install thermopane, double-paned glass or storm windows** to provide insulation. Also install reflective glass, sunshade screens or exterior shading devices, like awnings, to reduce heat gain in warm climates.

- **Install additional roof and wall insulation.** If the roof is in need of repair, adding insulation at the same time the roof is replaced will prove more cost effective than adding insulation to a roof in good repair. For uninsulated walls, consider application of rigid insulation. Also, consider insulating interior walls between heated and unheated spaces, like offices and storage areas.

- **Provide an enclosed entry way** for frequently used doors to minimize heat loss.

- **Consider measures to resolve the problem of open overhead service doors in maintenance and repair bays.** Open service doors are a major source of heat loss. If O & M measures for keeping doors closed are not feasible or effective, one or more of these conservation measures may be necessary:

  - Install **plastic door strips** in the service door opening. However, consider the limited useful life of these strips (average 2.5 years) and safety problems due to obscured vision.

  - Install **high-velocity air curtain doors**, but take into account the large amount of electricity required to operate the air curtains.

  - Install **photo-cell door operators** to automatically open and close doors. With frequent traffic circulation, there may be problems with damage to the doors and buses.

  - Disconnect forced-air heat and install an **infra-red heating system** to provide spot radiant heating in service bays. Optional systems include gas-fired infra-red black pipe with reflectors, gas-fired individual heaters and electric quartz heaters.

  - **Redesign the vehicular circulatory pattern** in order to make it possible to reduce operable service doors to a minimum.

- Install **direct-fired spot heaters** for service bay areas.

- **Interlock doors with thermostats** so that the heating system does not operate when doors are open.

Heating, Ventilating and Air Conditioning Systems

o **Install boiler economizers** on the boiler stacks to use the waste heat from flue gas. For instance, the heat from flue gas can be recovered to preheat boiler feedwater.

o **Install heat recovery devices,** such as thermal wheels or heat pipes, to recover waste heat from building exhaust, particularly in body shops, steam cleaning booths, paint booths and other areas where outside air provides the major portion of make-up air. Use recovered heat to preheat combustion air or make-up air.

o **Install insulation** on uninsulated ductwork, piping and other heated or cooled surfaces, like the condensate receiver for the boiler.

o **Install circulating fans** or induction-type fan units in areas with high ceilings to move heated air to the floor area.

o **Retrofit heating/cooling controls** to provide an economizer cycle.

o **Retrofit older oil burners** with high-efficiency flame retention devices and fuel-efficient burner nozzles.

o **Retrofit gas-fired heating system** to provide pilotless ignition.

o **Convert boilers** to the most efficient fuel source or install dual-mode boilers than can use different fuels, depending on which fuel is most efficient or cheapest.

Domestic Hot Water

o **Install insulation** on uninsulated hot water storage tanks and piping.

o **Use heat exchangers** to preheat domestic water with waste heat from condenser water.

o **Convert hot water heaters** to the most efficient fuel source; e.g., electricity to natural gas. Also, retrofit to pilotless ignition on gas equipment.

Solar and Alternative Energy

o **Install solar panels** to provide domestic hot water. Also, consider the feasibility of using solar panels for heating purposes.

o **Use passive solar design,** like trombe or heat storage walls, to make use of solar energy for heating.

- **Install waste oil heaters** in maintenance and shop areas to use waste crankcase oil. However, be certain to consider possible air pollution and the need for increased ventilation.

- **Install a heat pump** to provide heating and cooling or to reclaim waste heat, in conjunction with a traditional HVAC system.

- **Make multiple use of one energy source (cogeneration),** like using steam to generate electricity or power machinery as well as to provide heat.

- **Use landscaping** to moderate temperature extremes on north and south exposures and in paved areas like storage yards and parking lots. Also, consider use of landscaping as windbreaks.

STEP 6 - MAKE ENERGY CONSERVATION A PERMANENT PROGRAM

Implementing O & M actions and ECMs is not the last step of an energy conservation program. It is also essential that the efforts undertaken by the conservation team be made a permanent part of a facility's operations. In order to accomplish this goal, it will be necessary to:

- Establish an ongoing system for monitoring energy consumption in the facility and for making periodic checks of further conservation opportunities, and to

- Develop energy awareness among employees in order to obtain their support and involvement in saving energy.

An Energy Monitoring System

The forms provided for Step 2 are the essential ingredients of an ongoing energy monitoring system. A member of the conservation team should be given the responsibility of keeping the energy consumption data up to date. This regular information will make it possible to:

- Measure the success of the conservation program, and

- Identify potential problems as indicated by increases in consumption.

In order to keep everyone informed of the effects of the conservation program, it's a good idea to have a prominent place for displaying energy consumption trends in the facility, such as a centrally located bulletin board, or regular features in employee newsletters and management reports.

In addition to the routine monitoring of the facilty's energy consumption, a member of the conservation team, perhaps the facility engineer or energy conservation coordinator, should be responsible for keeping track of new developments in energy systems, which he or she can report to the team as new measures to consider. The team itself should arrange to meet periodically to review the conservation program and to conduct periodic surveys of the building's energy systems to identify problems that may have arisen since the original program was developed.

Finally, it is important to make certain that the experience gained from the conservation program is incorporated into other areas. For instance, the results of the conservation program at one facility should be assessed for application at other buildings and included in the design of new facilities.

Employee Energy Awareness

Last, but by no means least, it is of vital importance to develop energy awareness among the system's employees. As with most programs, conservation efforts are not likely to succeed without the cooperation of the people who use the facility. In some cases, the need for employee support is obvious, especially if implementation of a conservation measure requires modifying work routines (e.g., keeping service bay doors closed) or getting used to lower heat levels or different light sources. In other cases, employee support is useful simply to provide general interest and enthusiasm for the program's goal of saving energy.

Some practical suggestions for developing energy awareness and involving employees in energy conservation follow:

- Establish an employee suggestion program for ways to save energy, with recognition and/or cash incentives.

- Set up a graphic display of energy consumption and savings in the facility.

- Design a logo and develop a mascot and slogan to promote energy conservation. Promotional materials could include lapel pins, bumper stickers and prominently posted reminders to save energy by keeping doors closed and turning off lights when leaving a room.

- Provide employees with brief seminars and brown bag lunches to explain the conservation program and to encourage them to save energy at home as well as at work. An informational brochure on conservation at home and at work would encourage employees to be aware of how saving energy can be of value to them. The U.S. Department of Energy's brochure "Low Cost/No Cost Energy Savers" (DOE/CS-0174) is one such publication. Contact local utilities and state or local energy offices for similar brochures.

- Develop a friendly rivalry among different facilities or among different work groups within the same facility to see which group can save the most energy.

- Expand the conservation team approach to all employees, using shifts and work crews as "quality circles" for identifying potential energy savings.

- Keep employees informed of the program through newsletters, special bulletins and other means.

GLOSSARY OF COMMON ENERGY TERMS

Air Changes: The replacement of air in a room over a period of time. Often expressed in cubic feet per minute (CFM).

Alternate Energy Source: A non-depletable energy source such as solar, geothermal or wind energy.

ASHRAE: American Society of Heating, Refrigeration and Air Conditioning Engineers.

Average Occupancy: The number of people in a building over a given period.

Ballast: A transformer used in the starting circuit for fluorescent and high intensity discharge lamps.

Base Period: A selected time unit, usually a year, expressed in energy consumption units or dollar amounts, to which all future usage or costs are compared.

Benefit/Cost Ratio (B/C): A measure of cost-effectiveness that compares the **present value** of an energy conservation measure to its **first cost**.

BIN Method: A method developed jointly by the Armed Forces to estimate energy requirements for comfort heating in buildings. Bin data for many U. S. cities are contained in the manual **Engineering Weather Data** (see **Resources**).

British Thermal Unit (BTU): A unit of energy equal to the amount of heat required to raise one pound of water one degree Fahrenheit, commonly expressed in millions of BTUs (MBTU) for energy conservation studies.

Building Envelope: The external surfaces of a building, such as walls, doors, windows, roof and floors, which enclose conditioned spaces and through which thermal energy may be transferred to or from the exterior.

CFM: Cubic feet per minute--usually refers to air change.

Chillers: A refrigeration machine using heat or mechanical energy to drive a compressor to generate chilled water.

Cogeneration: The multiple use of one energy source, such as the use of steam to generate electricity or to power machinery as well as to provide heat.

Cold Deck: A cold air chamber forming part of a ventilating unit.

Conditioned Space: Any interior space which is contained within exterior walls and which is heated or cooled directly or indirectly by an energy-using system.

Convection: A method of heat transfer where heat moves by motion of a fluid or gas, usually air.

Cooling Tower: A device that cools water directly by evaporation.

Cycling: A means of reducing electrical energy loads by scheduling the operation of machinery so that equipment operates in sequence rather than simultaneously.

Damper: A device used to vary the volume of air passing through an air outlet, inlet or duct.

Deadband Thermostat: A thermostat that allows separation of cooling and heating setpoints so that a "zero" energy band is created where neither heating nor cooling is required.

Degree Days: The average of the daily maximum or minimum temperatures of any given day, which provides a measure of the severity of the weather. The degree day value for any given day is the difference between 65°F and the mean daily temperature. Example: with a mean daily temperature of 50°F, the number of degree days is 15. Degree day data are available from the Weather Service, usually as heating or cooling degree days.

Demand Load: The requirement of electric energy measured in 15 minute cycles for commercial operations. The price of electric usage is directly related to the level of this demand. The higher the demand, the higher the cost per electrical unit.

Discount Rate: The rate by which money is discounted over time: for example, to account for escalation in energy and related costs of a conservation measure.

D.O.E.: The Department of Energy.

Economizer Cycle: A method of operating a ventilation system to reduce refrigeration load. Whenever the outdoor air conditions are more favorable--that is, cooler--than return air conditions, the quantity of outdoor air is increased.

Efficiency, Overall System: The ratio of the useful energy (at the point of use) to the thermal energy input for a designated time period, expressed in percent.

Energy: The capacity for doing work. Energy takes a number of forms which may be transformed from one into another, such as thermal (heat), mechanical (work), electrical. Energy is measured in customary units, such as kilowatt-hours (kwh) or British Thermal Units (BTU).

Energy Conservation Measure (ECM): A modification or **retrofit** of an existing energy conserving system designed to increase energy efficiency and requiring a significant capital investment.

Energy Load: The amount of energy required to operate a piece of equipment or an energy consuming system, like lights and ventilating fans.

Energy Management: The overall engineering/management function of providing for a facility's energy needs in an efficient, cost-effective way.

Energy Management Control System: A centralized, computer-operated system designed to ensure the most efficient use of a building's lighting, cooling and other energy-consuming systems.

Energy Utilization Index (EUI): A reference which expresses the total energy (fossil fuel and electricity) used by a building in a given period (month, year) in terms of BTUs/gross conditioned square feet.

First Cost: The initial cost of implementing an energy conservation measure, including the costs of installation, equipment, system modification and related elements.

Foot-candle: A measurement of illumination. One foot candle is the illumination at a distance of one foot from a standard candle.

Glazing: Glass or similar translucent or transparent material used to cover a window or door opening.

Gross Square Feet (GSF): The total number of square feet contained in a building envelope, using the floors as the area to be measured.

Heat Gain: As applied to HVAC calculations, it is that amount of heat gained by a space from all sources, including people, lights, machines, sunshine, etc. The total heat gain represents the amount of heat that must be removed by refrigeration or other means from a space to maintain indoor comfort conditions.

Heat Loss: The sum cooling effect of the building structure when the outdoor temperature is lower than the desired indoor temperature. It represents the amount of heat that must be provided to a space to maintain indoor comfort conditions.

Heat Pump: A refrigeration machine that can be used to either heat or cool a building. When used for heating, it extracts heat from a low temperature source, such as outside air, and transfers it to a point where it can be used.

Heat Transfer Coefficient: See **"U" Value.**

Horsepower: A British unit of power, 1 hp = 746 watts.

Hot Deck: A hot air chamber forming part of a ventilation unit.

Humidistat: An instrument which measures changes in humidity and controls a device(s) for maintaining a desired humidity.

Humidity, Relative: A measurement indicating the moisture content of air.

HVAC: Heating, ventilating and air conditioning.

HVAC System: A system that provides either collectively or individually the processes of comfort heating, ventilating, and/or air conditioning.

Infiltration: The process by which outdoor air leaks into a building by natural forces through cracks around doors, windows and elsewhere.

Kilowatt: A measurement of electrical energy, equal to 1,000 watts or 3,413 BTUs.

Life Cycle Cost: A means of evaluating the cost-effectiveness of an energy conservation investment that takes into account the time value of money by evaluating the cost of the measure over its useful life, including operating and maintenance costs.

Load Factor: A percentage of the **rated load** of a machine or electrically-powered system, determined by dividing the actual operating amps by the maximum rated amps.

Lumen: A unit to measure the intensity of a lighting source.

Luminaire: A light fixture.

Make-up Water: Water supplied to a system to replace that lost by blow down, leakage, evaporation, etc.

Make-up Air: See **Outside Air.**

Net Annual Savings: The dollar savings of an energy conservation measure, as determined by subtracting the annual operating costs (if any) of the conservation measure from the savings in energy costs.

O & M (Operating and Maintenance): A modification in the operation or maintenance of a building's energy systems requiring no or only minimal cost and designed to increase energy efficiency.

Outside Air (OSA): Air taken from outdoors as make-up air for the HVAC system and therefore, not previously circulated through the HVAC system.

Pay-Back Period: The time required to recover the **first cost** of a conservation investment, conventionally expressed in years and calculated by dividing the first cost by the **net annual savings.**

Present Value: The value of the future savings of an energy conservation investment expressed in current dollars, or determined by the **net annual savings** multiplied by the **present worth factor.**

Present Worth Factor: The relationship between the **discount rate** and the estimated or operational life of an energy conservation measure.

Radiant Heat: The sensible heat produced by a radiator or infrared device that heats objects rather than surrounding air.

Radiation: The transfer of heat from one body to another by heat waves without heating the air between the bodies.

Rated Load: The energy requirements of a piece of equipment or machinery, expressed in horsepower or voltage and amps.

Retrofit: A modification of an existing energy system for the purpose of increasing the energy efficiency of the system.

Return on Investment (ROI): A means of evaluating the cost-effectiveness of an energy conservation investment by including the depreciation of the equipment in the calculation. ROI is usually expressed as a percentage.

R-Value: The resistance to heat flow.

Simple Pay-Back: A means of evaluating the cost-effectiveness of an energy conservation investment that does not take into account the time value of money or depreciation of the investment. See **Pay-Back Period.**

Temperature Difference (TD or _T): The difference between the minimum outside temperature and the inside temperature of a building over time. See **BIN Method.**

Therm: A unit of gas fuel containing 100,000 BTUs and equal in volume to 100 cubic feet.

Thermal Conductance: See **"U" Value.**

Ton of Refrigeration: A means of expressing cooling capacity: 1 ton = 12,000 BTU/hour cooling (removal of heat).

Transmission: The amount of **heat loss** through windows, walls and other parts of the **building envelope.**

"U" Value: A coefficient expressing the thermal conductance of a wall, roof, door or other structural element of a building, usually in BTUs per square foot/hour/degree of temperature difference.

Zone: An area composed of a building, a portion of a building, or a group of buildings affected by a single device or piece of equipment.

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